CMTFO

Experiments on Tore Supra 3D particle transport @ LCFS & effects on core rotation

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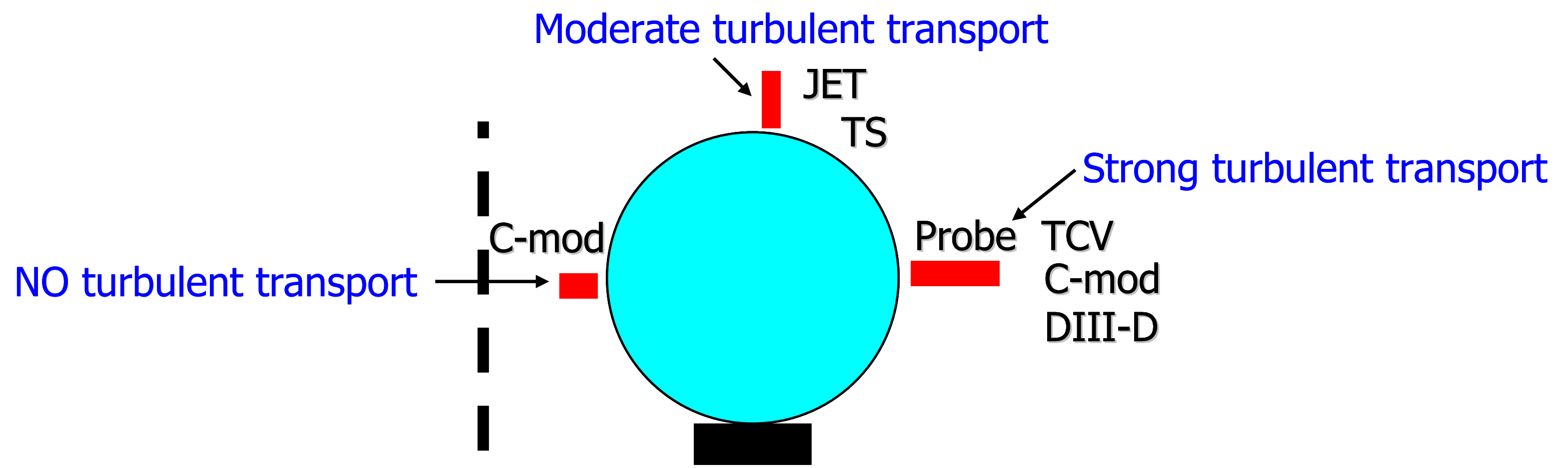
Turbulence asymmetry plays a major role in SOL

I. LOCAL turbulent transport DOES NOT represent SOL width : BALLOONING



→ drive strong // flows along field lines

II. Ballooning + symmetry breaking (divertor/limiter)

→ Influence on core particle momentum *(C-mod, LaBombard TCV, Camenen)*

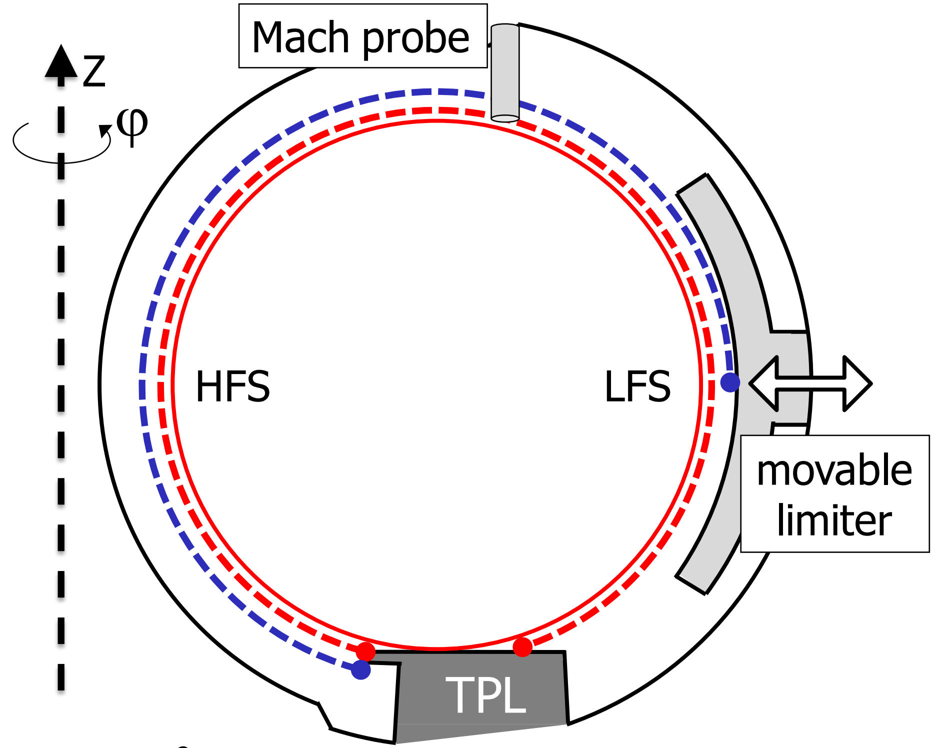
Toroidal & transversal rotation

Resolving the particle flux asymmetry in TS SOL

Field line tailoring with
movable discrete limiter
(intersection @ LFS midplane)

	$L_{//}$	λ_n
" free" SOL	85 m	4.2 cm
" tailored " SOL	65 m	1.5 cm

$\lambda_n \not\propto L_{//}$ (→ non uniformity)



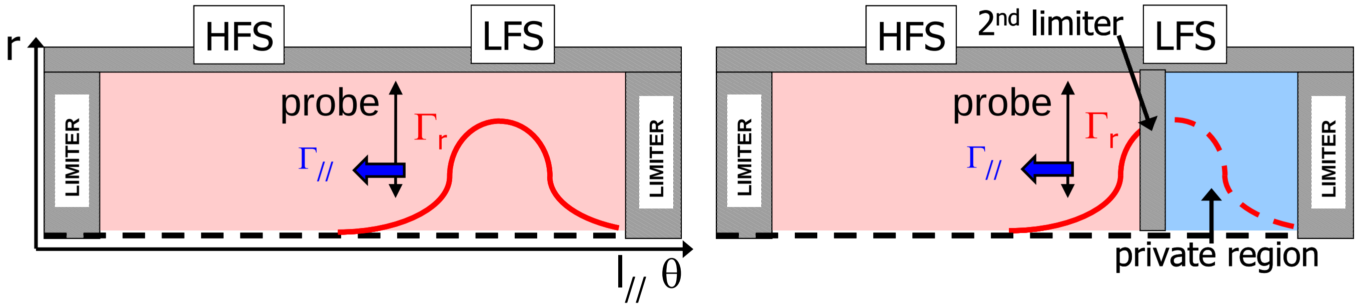
Flux conservation in SOL : $n(r), M_{//}(r) \rightarrow \int_{L_{//}} \Gamma_r dl_{//}$

Second limiter @ LFS midplane : ½ of line integrated radial flux is isolated

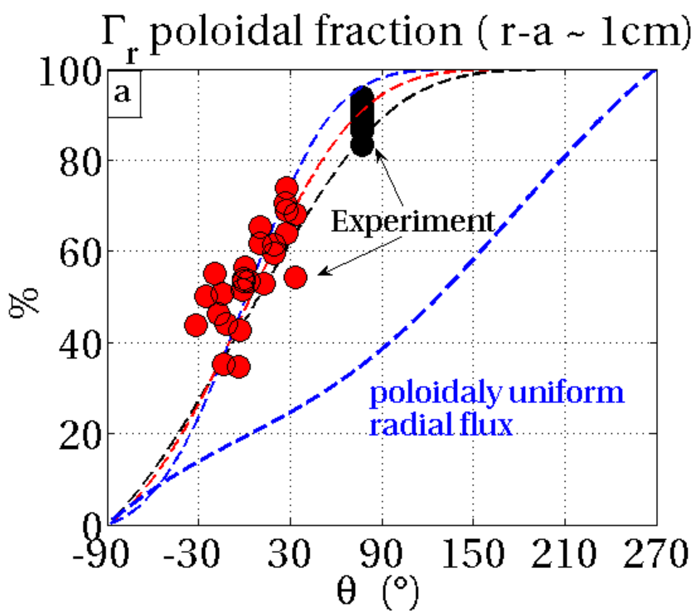
→ Γ_r is centered @ LFS midplane

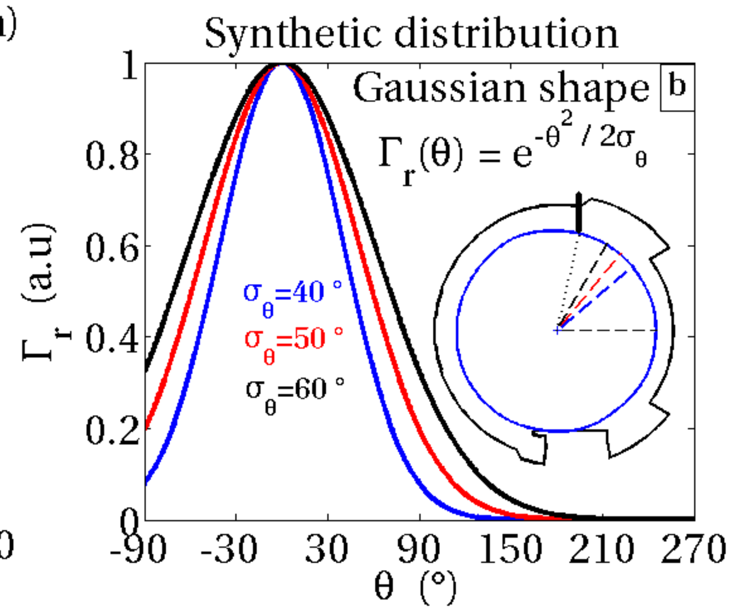
Resolving the particle flux asymmetry in TS SOL

Scan of the poloidal extent of the private region



$$f_S = \frac{\int_{//}^{private} \Gamma_r dl_{//}}{\int_{//}^{reference} \Gamma_r dl_{//}}$$



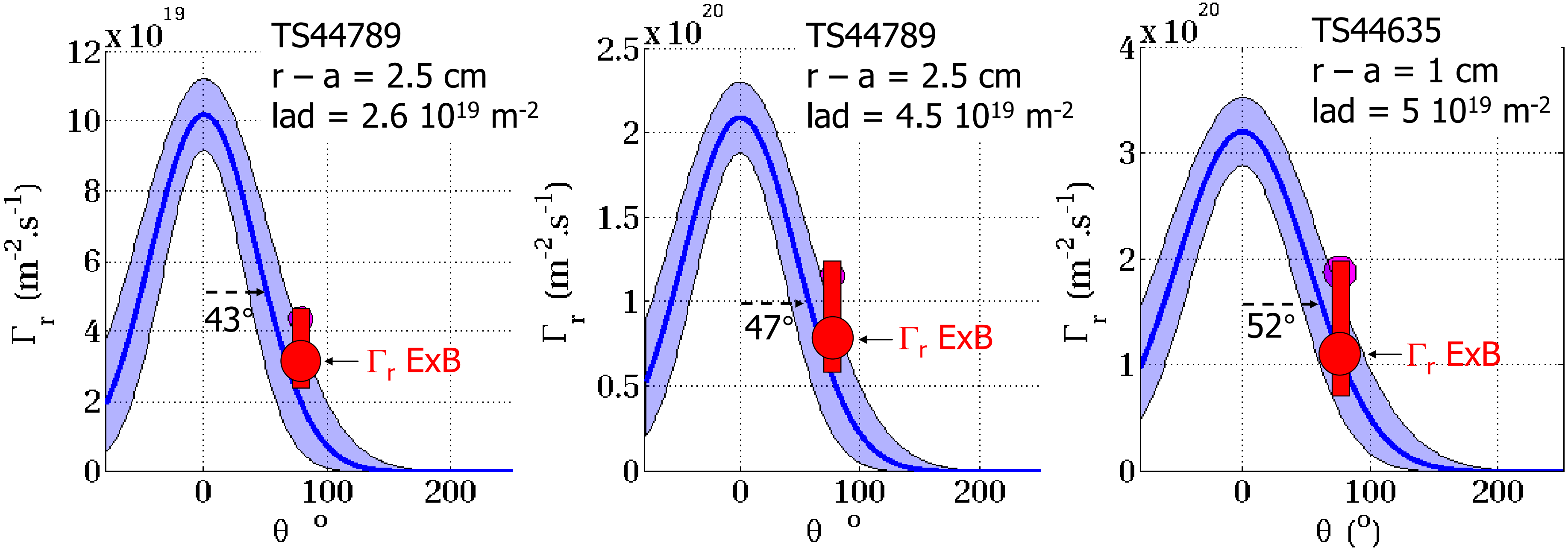


Γ_r centered @ outboard midplane in a narrow poloidal section (±50°)

Local ExB transport is consistent with ballooning

Mach probe → $\Gamma_r(\theta)$ test distribution (Gaussian)

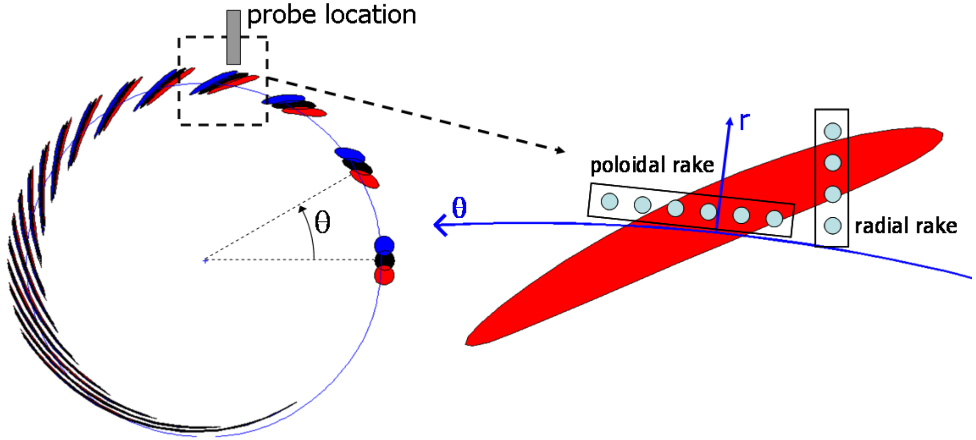
Poloidal rake probe → fluctuations induced radial flux : <u>interchange-like</u>

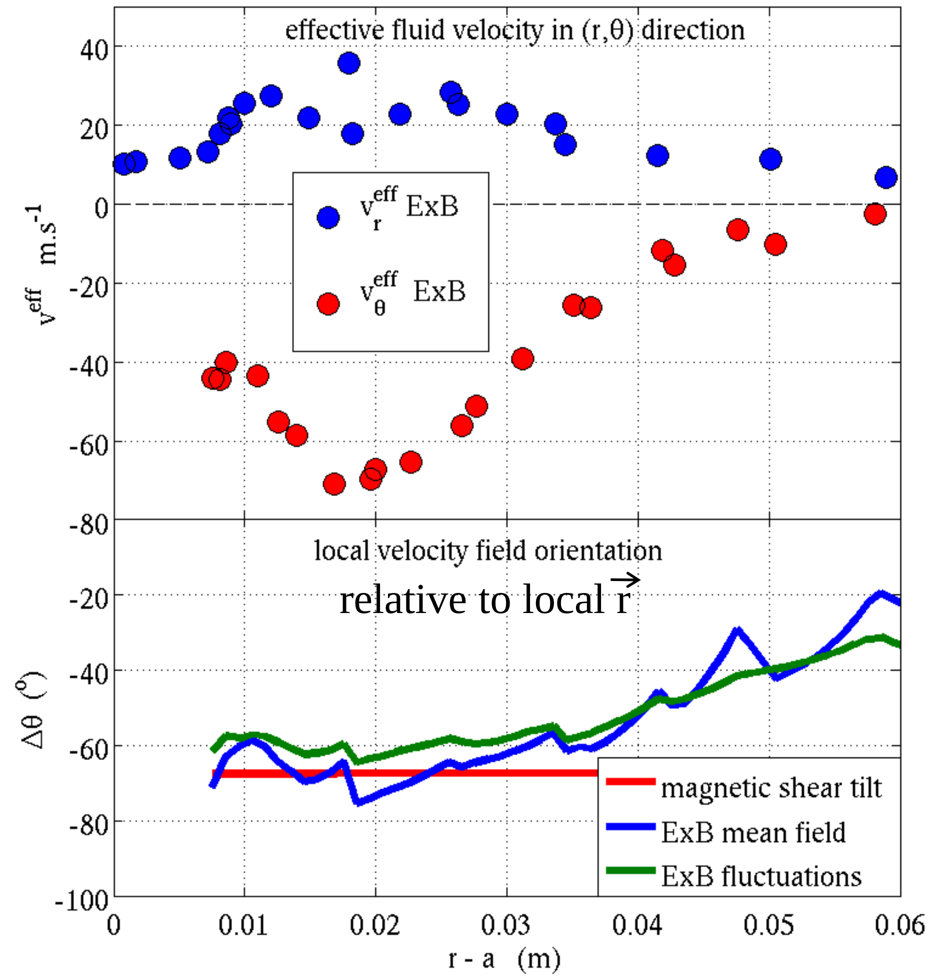


The flux ballooning is due to an asymmetry of the turbulence : $k_{//} > 0$

Modes destabilized @ LFS midplane → influence of magnetic shear along field lines

Balloonning : magnetic shear tilts the structures





In the plasma frame ($<E_r>_t$ corrected) :

- assume filament velocity purely radial @ LFS midplane

- assume flux tube aligned structures

→ local velocity is constrained by magnetic shear

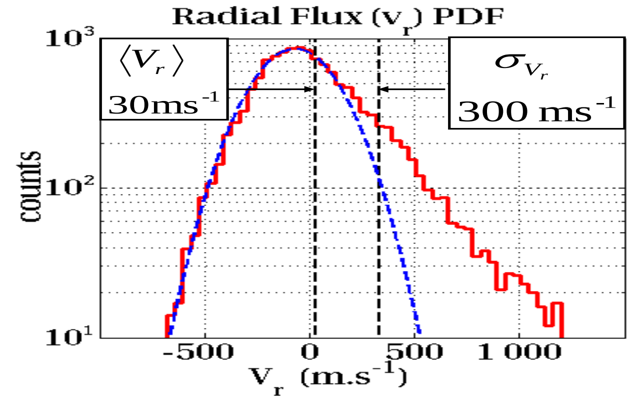
→ Reynolds Stress. Surface average depends on plasma symmetry

Symmetry breaking fixes // & ⊥ Reynolds stress sign

LCFS & time averaged Reynolds stress : $\langle n v_r v_{//} \rangle$ & $\langle n v_r v_\perp \rangle$

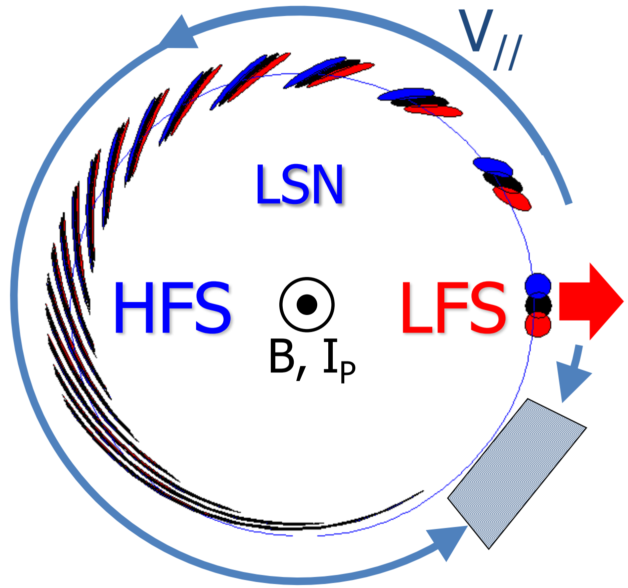
$\langle n v_r v_\perp \rangle$: magnetic shear

$\langle n v_r v_{//} \rangle$: inward flux of SOL momentum



$$B \times \nabla B \downarrow$$

LSN	USN
$\langle n v_r v_\perp \rangle < 0$	$\langle n v_r v_\perp \rangle > 0$
$\langle n v_r v_{//} \rangle < 0$	$\langle n v_r v_{//} \rangle > 0$



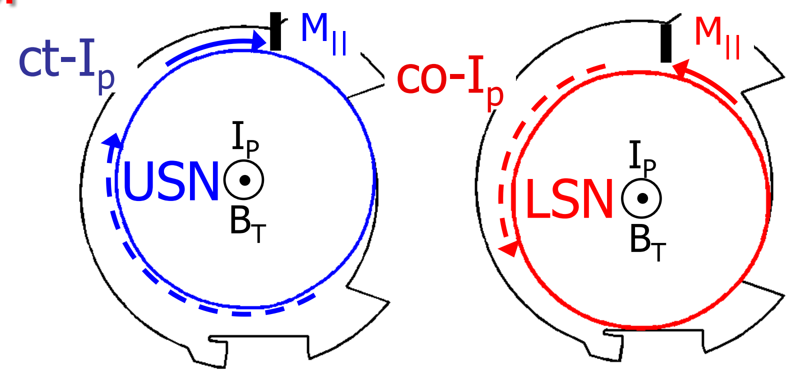
Edge : $\rho \leq 1$

$$V_{//}^{LSN} > V_{//}^{USN}$$
$$V_{\perp}^{LSN} > V_{\perp}^{USN}$$

Experiments on TS confirm the behavior

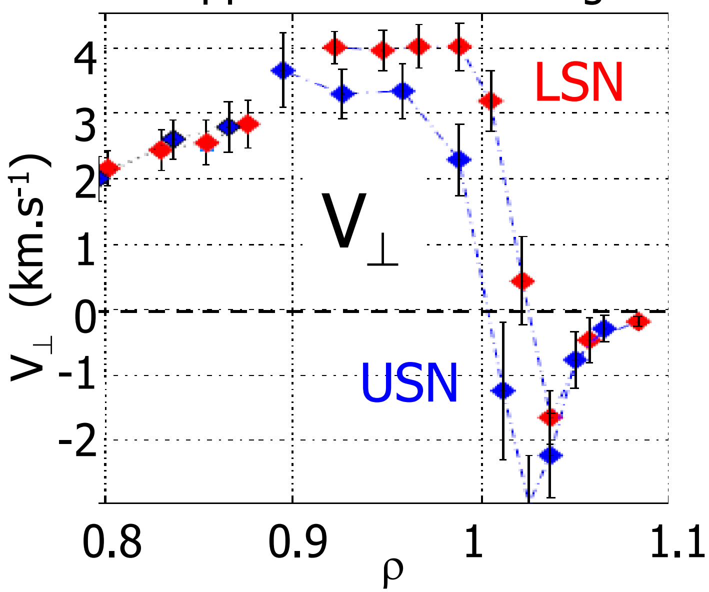
Edge : $\rho \leq 1$

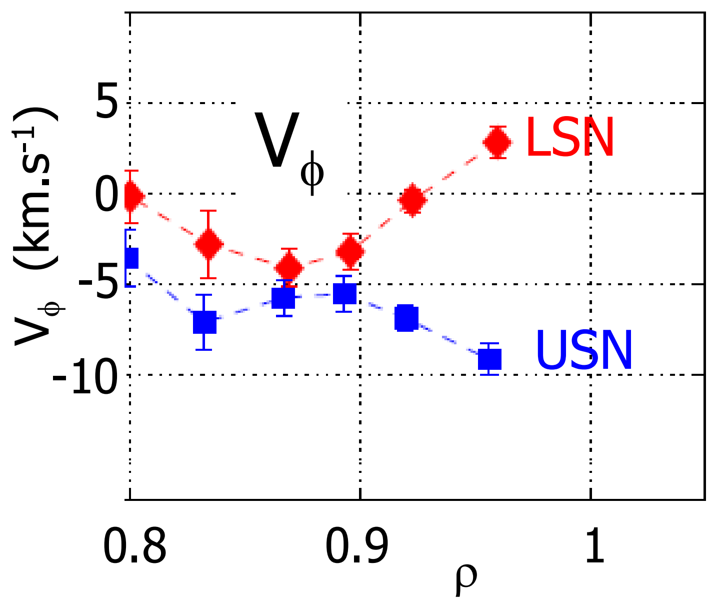
$$V_{//}^{LSN} > V_{//}^{USN}$$
$$V_{\perp}^{LSN} > V_{\perp}^{USN}$$



CXRS

Doppler back-scattering





Conclusion and prospects

Probable influence of SOL transport on core rotation:

- Revealed by experiments

- In agreement with simple ballooning-symmetry breaking principles

  - // velocity by inward " viscous" transfer from SOL
  - $\perp$ velocity by magnetic shear induced Reynolds stress

Can 3D simulations capture the phenomena ?

What are the optimum plasma shapes to enforce shear layers ?